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THE GRAVITY MODEL AND TRADE EFFICIENCY: A STOCHASTIC FRONTIER ANALYSIS OF POTENTIAL TRADE

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The Gravity Model and Trade Efficiency:

A Stochastic Frontier Analysis of Potential Trade

ABSTRACT

The opening up process of the eastern European countries is characterised by an increasing degree of trade integration with their Western neigbouring countries. Typically, the degree of East West trade integration is assessed by comparing actual trade volumes with potential trade volumes projected from the gravity model parameters estimated for a group of countries that best represent normal trade relations. This approach, however, does not compare trade levels against a maximum level of trade feasible for the group of eastern European countries. This paper by using a stochastic frontier specification of the gravity model is able to identify the efficiency of trade integration relative to maximum potential levels. The findings, based on a panel data set of bilateral exports from 17 Western European countries to the 10 new member states over the 1994 2007 period, indicate a high degree of East West trade integration close to two thirds of frontier estimates, suggesting a low degree of trade resistances.

JEL Classification: C33, F14, F15

Keywords: Gravity model, Potential trade, Efficiency scores

1. INTRODUCTION

Not unlike the drive to increase trade between the established European Union (EU) member countries as part of a customs union, the opening up process of the eastern European countries began with trade integration. Strong bilateral trade links were formed in advance of formal EU entry. After the Council for Mutual Economic Assistance (CMEA) system[1] was dissolved in the early 1990s, a new era of trade expansion was ushered in, culminating in the Western European countries becoming the main trading partners for the excommunist countries.

Figure 1 plots each new EU member country's share of world trade (exports plus imports) with the Western European countries. By 1994, Western Europe had already become important trading partners for the group of ten, implying an almost immediate release of economic ties from the former Soviet Union. Trailing behind its counterparts, Lithuania was initially the slowest to open up its trade links, but increased its trade shares by 1.5 times within a decade. Slovakia experienced an even more dramatic reorientation of trade westwards, rising by two thirds to its peak levels in 2003. Conducting about half of its trade with the Western countries in 1993, the trade shares for Bulgaria and Romania depict an almost parallel trend, but with the latter maintaining a ten per cent lead over the former. Much like Bulgaria's path, the trade shares for Estonia and Latvia have ended up like they started albeit with some variation in between. The trade shares for the top four ranking countries, namely the Czech Republic, Hungary, Poland and Slovenia remain relatively stable at around 65 per cent throughout the period.

[Insert Figure 1 here]

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[1] The CMEA system, also known as COMECON, was formed in 1949 to co-ordinate economic development and industrial production between the Soviet Union and its member countries.

A two stage gravity approach to projecting East West trade volumes is the usual route to assessing bilateral trade performance. In the first stage, the gravity model of trade is estimated for a group of countries that best represent normal trade relations. In its basic form, the standard gravity equation explains bilateral trade as a function of the economic size of two countries and the distance between them (Tinbergen 1962; Pöyhönen 1963). The augmented version additionally includes income per head for both countries and other trade impeding or trade stimulating factors (Bergstrand 1989).

In the second stage, the gravity model parameters that fit a model of a normal country's geographic trade patterns are used to project the expected trade flows in an East West direction. The trade flows predicted by the model can then be compared with actual trade flows to assess the likelihood for future expansion or depletion of trade links between a pair of countries. Whereas a value in excess of unity suggests remaining potential for trade growth, a value of less than unity suggests trade potential is already exhausted. In this way, the potential to actual trade ratios are informative as to the degree of East West trade integration under normal conditions.

The two stage approach to trade projections pervades the empirical literature (see, for example, Baldwin 1994; Gros and Gonciarz 1996; Stack and Pentecost 2010). In assuming full economic liberalisation, these studies define East West potential trade in terms of the sample average, usually the Western European countries. In other words, the mean effects of trade determinants are estimated, implying potential trade is assessed using the mean predicted values as a benchmark (Armstrong et al., 2008). The predictive ability of the gravity model, however, declines as the year of the inserted values increasingly departs from the historical average. Moreover, these studies do not gauge trade performance against a maximum possible level of potential trade defined by a stochastic frontier.

This paper assesses potential trade against a maximum level of trade feasible for the group of 10 new member states (NMS) using a stochastic frontier approach to estimating the gravity equation. Specifically, a trade frontier representing the maximum possible level of bilateral trade is constructed for a panel of exports from 17 Western European countries to the new EU member countries over the 1994 2007 period, covering the transformation phase from communism to EU accession. The efficiency scores are then generated from this frontier specification of the gravity model. If two countries achieve an efficient level of trade, they will operate on the trade frontier and will realise their maximum trade potential otherwise deviations of observed trade levels from the trade frontier indicate inefficient levels of trade, implying scope for further trade expansion. The frontier specification of the gravity model is similar in approach to that used by Drysdale et al. (2000) who consider China's trade efficiency, Kalirajan and Singh (2008) who conduct a comparative analysis of export potential for China and India and Armstrong et al. (2008) who compare trade performance in East Asia and South Asia.

The efficiency scores suggest a high degree of East West trade integration, with each new member state achieving on average two thirds of frontier estimates over the 1994 2007 period. The high efficiency scores indicate a low degree of trade resistances. The main exceptions to the broad pattern of high integration levels suggest greatest potential for trade expansion vis à vis Greece, Iceland, Norway and the UK.

The layout of this paper is as follows. Section 2 sets out the gravity model specification, distinguishing between the conventional gravity equation and the stochastic frontier gravity equation. The data sources and the expected coefficient signs are also given in this section. The results in Section 3 are split between the gravity model coefficient estimates and the efficiency scores of potential trade. Section 4 concludes.

2. MODEL SPECIFICATION AND DATA

2.1 The Gravity Equation

The gravity model specification for calculating trade volumes (Baldwin 1994; Gros and Gonciarz 1996; Nilsson 2000) is typically of the following form:

$$
\begin{aligned}
TRADE_{ij}^{t} = {} & \beta_0 + \beta_1 GDP_i^t + \beta_2 GDP_j^t + \beta_3 DIST_{ij} + \beta_4 GDPPC_i^t + \beta_5 GDPPC_j^t \\
& + \sum_{g=1}^{G} \gamma_g Z_{ij} + \sum_{k=1}^{K} \alpha_k X_{ij}^{t} + \varepsilon_{ij}^{t}
\end{aligned}
\tag{1}
$$

where $TRADE_{ij}^{t}$ are the bilateral trade flows between countries i and j over a given time period t; GDP_i^t and GDP_j^t denote the economic size of both countries; $DIST_{ij}$ is the geographic distance between their economic centres; and $GDPPC_i^t$ and $GDPPC_j^t$ are the respective countries' per capita income levels capturing factor endowments in the exporting country and consumption patterns in the importing country. Equation (1) also includes a vector of time invariant explanatory variables, Z_{ij}; a vector of time varying trade stimulating and trade resisting variables, X_{ij}^{t}; and the error term, ε_{ij}^{t}.

East West trade projections of trade flows for the countries of interest typically use the gravity model parameters estimated for a group of countries that best represent normal trade relations. The main drawback to this approach is that the potential to boost trade is defined relative to the sample average rather than in terms of a maximum level feasible for a given pair of trading partners. Measuring trade potential against mean predicted values can be problematic because the predictive ability of the gravity model declines as the year of the inserted values increasingly deviates from the sample average.[2]

Under the stochastic frontier analysis (SFA) approach, the gravity equation of trade determinants identifies the trade frontier. The resulting frontier levels of trade, i.e. the maximum possible level of trade for a given bilateral trading pair, is impacted by a random error term which can be positive or negative thereby allowing the stochastic frontier trade level to vary about the deterministic part of the gravity equation. Observed trade levels can then be compared against this frontier level of trade for each bilateral trading pair to assess the scope for trade expansion. The next section provides a detailed exposition of this approach.

2.2 The Gravity Equation estimated using Stochastic Frontier Analysis

Developed independently by Aigner et al. (1977) and Meeusen and van den Broeck (1977), stochastic frontier analysis (SFA) has been used extensively in the assessment of firm performance. In its traditional application, SFA specifies a production frontier representing the maximum output that can be produced from a given level of inputs. Fully efficient firms operate on the frontier such that observed and frontier levels of output coincide, while (technically) inefficient firms operate at a point within the frontier, signifying a shortfall between the observed and the maximum possible levels of output. The latter thus implies scope for further expansion of outputs given current input bundles. Therefore, in the case of a production function, technically inefficient production refers to

[2] This is because the width of the confidence intervals is smallest when the inserted values are equal to the historical average but widens sharply – and thereby increases the prediction error of the regression – as the inserted values depart from the sample mean.

the degree to which actual output falls short of potential output. Analogously, SFA can be used to define a trade frontier whereby inefficient trade performance refers to the degree to which actual trade falls short of the maximal, frontier level of trade. This is achieved by modifying the conventional gravity model (equation 1), as follows:

$$TRADE_{ij}^{t} = f(GDP_i^t, GDP_j^t, DIST_{ij}, GDPPC_i^t, GDPPC_j^t, Z_{ij}, X_{ij}^{t})\exp(v_{ij}^{t})\exp(-u_{ij}^{t}) \qquad (2)$$

where bilateral trade and its determinants are defined as above and the error term, ε_{ij}^{t}, in equation (1) is now comprised of two parts, viz., a two sided error element, v_{ij}^{t}, representing statistical noise due to measurement error and a one sided inefficiency element, u_{ij}^{t}, representing a measure of trade performance. Whereas the former term is assumed to follow a normal distribution, $v_{ij}^{t} \sim iid\ N(0,\sigma_v^2)$, as is typical of the conventional gravity specification, the latter term, u_{ij}^{t}, is assumed to be distributed independently of the random error and the regressors. This one sided inefficiency component is a non negative random variable representing technical inefficiency (TE) and can identify the degree to which observed trade levels deviate from the maximal possible. Taking a value between zero and unity, a value of zero would imply that the actual and potential trade levels coincide while values tending towards unity would indicate scope to raise actual trade levels nearer maximum levels. These deviations from the maximal trade level can occur due to multilateral resistances (Anderson and van Wincoop, 2003), which are often unobservable or difficult to quantify[3]. In effect, trade resistances can lead to an inefficient level of trade performance.

[3] Unobservable transition-related factors include the development of financial institutions, the building of transport facilities and the required amount of time it takes for businesses to establish new contacts and to acquire new skills (Bussière et al., 2005).

Following Aigner et al. (1977), equation (2) is operationalised as a pooled frontier wherein the parameter values are obtained by maximum likelihood estimation (MLE). Along with the gravity model parameters, estimates for the variance of the composed error term, $\sigma^2 = \sigma_v^2 + \sigma_u^2$, and the ratio of the standard deviation of the inefficiency component to the standard deviation of the random error component, $\lambda = \sigma_u / \sigma_v$, are also generated. The latter assesses the degree of inefficiency relative to the random error and when statistically significant, justifies the use of the SFA approach. A further test for the presence of technical efficiency in the model is undertaken via a one sided likelihood ratio (LR) test of the null hypothesis, $H_0 : \sigma_u^2 = 0$, against the alternative, $H_0 : \sigma_u^2 > 0$. Failure to reject the null hypothesis leads to the SFA model to reduce to an OLS model.

Following parameter estimation, the point estimates of inefficiency can then be obtained as the mean of the conditional distribution of u given ε (Jondrow et al. 1982):

$$f(u/\varepsilon) = \frac{f(u,\varepsilon)}{f(\varepsilon)} = \frac{1}{\sqrt{2\pi}\sigma_v \Phi(-\tilde{\mu}/\sigma_v)} \cdot \exp\left\{-\frac{(u-\tilde{\mu})}{2\sigma^2}\right\}$$

$$E(u_{ij}^t \middle| \varepsilon_{ij}^t) = z_{ij}^t + \sigma_v \left[\frac{\phi(-z_{ij}^t/\sigma_v)}{\Phi(z_{ij}^t/\sigma_v)}\right] \tag{3}$$

where $z_{ij}^t = \varepsilon_{ij}^t - \sigma_v^2/\sigma_u$ and $\phi(.)$ and $\Phi(.)$ are the standard normal density and cumulative distribution functions, respectively. The technical efficiency (TE) estimates for each country pair are then determined as $TE_{ij}^t = \exp(-u_{ij}^t)$.

The full model specification of trade determinants between the Western European countries and the new EU member states is specified as follows:

$$\begin{aligned} EXP_{ij}^t = {} & \theta_0 + \theta_1 GDP_i^t + \theta_2 GDP_j^t + \theta_3 DIST_{ij} + \theta_4 DGDPPC_{ij}^t + \theta_5 LOCK_j + \theta_6 COL_{ij} \\ & + \theta_7 RER_i^t + \theta_8 RER_j^t + \theta_9 EU04_{ij}^t + \theta_{10} EU07_{ij}^t + v_{ij}^t - u \end{aligned} \tag{4}$$

where EXP_{ij}^t are the bilateral export flows from 17 Western European countries to 10 new member countries over the period 1994 2007, GDP and distance are as before and GDP per capita is restated in relative terms as the absolute difference in the logged values of GDP per capita income levels, $DGDPPC_{ij}^{t} = \left| ln\,GDPPC_{i}^{t} - ln\,GDPPC_{j}^{t} \right|$, as a proxy for differences in consumption patterns. The vector of time invariant explanatory variables, Z_{ij}, comprises a binary coded dummy for landlocked countries, $LOCK_{j}$, and a dummy denoting common colonial ties, COL_{ij}, as an indicator for institutional proximity. The vector of time varying explanatory variables, X_{ij}^{t}, refers to the real exchange rate for both countries, RER_{i}^{t} and RER_{j}^{t}, to capture currency price movements. Two additional dummies account for the EU accession of eight new member states in 2004, $EU04_{ij}^{t}$, and the later accession of Bulgaria and Romania in 2007, $EU07_{ij}^{t}$. All non dummy variables in equation (4) are estimated in logarithmic form.

In its basic form, the standard gravity equation posits that bilateral trade increases with national income and declines with the distance between them.[4] Larger countries tend to trade more, consistent with the conduct of much of intraindustry trade between the advanced countries (Helpman and Krugman 1985), hence the GDP coefficients for both countries should be positively signed. Countries located within close proximity incur lower transport costs which boosts trade, implying the distance coefficient, $DIST_{ij}$, should be negatively signed.

In the augmented version of the gravity model, the separate roles for per capita income identified by Bergstrand (1989) are merged by Gruber and Vernon (1970) into the per capita income differential as an indirect way of testing the Linder (1961) hypothesis. Although Linder presented no formal model, the demand based theory suggests that if an importing country's aggregated preferences for goods are similar to an exporting country's consumption patterns, country j will develop industries similar to country i. Put simply, the Linder hypothesis is concerned with income similarities. A

[4] See Anderson (1979) who was the first to derive the gravity equation using the properties of the expenditure system and the Armington (1969) assumption that goods are differentiated by country of origin. A gravity equation with trade-inhibiting factors was also derived.

negative coefficient for the per capita income differential, $DGDPPC_{ij}^{t}$, suggesting trade is positively related to consumers with similar per capita incomes and therefore having similar consumption patterns, indicates support for the Linder hypothesis. On the other hand, a positive coefficient will ensue if trade is driven more by differing per capita incomes consistent with the Heckscher Ohlin model (1919, 1933) of relative factor abundance.

The dummies included in equation (4) are equal to unity if the new member countries are landlocked, $LOCK_j$, or if the EU countries share a history of colonial ties, COL_{ij}. Opposing trade effects are expected for the respective dummy coefficients. As the overland costs of transporting goods tends to be higher than shipping costs, landlocked countries located in the heart of Europe tend to be disadvantaged in trade terms because of their geographical position. In contrast, past governance of another country can boost present economic links because a coloniser may well have contributed to the state of the institutions of the colonised.

Motivated by the gravity model derived by Bergstrand (1985), which explicitly includes an exchange rate index to account for location dependent trade costs, the real exchange rate for both countries, RER_i^t and RER_j^t, is included to capture the trade effect of currency price movements. Micco et al. (2003) include the RER for both countries against the US dollar to control for valuation effects, arguing that a depreciation of the US dollar exchange rate can lower the US dollar value of intra eurozone trade. The real exchange rate can also be interpreted as a measure of national competitiveness. An increase in the US real exchange rate (implying a depreciation of the US dollar) improves price competitiveness with consequential beneficial effects on US exports in foreign markets, but with detrimental effects on US imports from abroad. Accordingly, the RER coefficients are expected to be negatively signed.

Accounting for European intraregional integration, positive effects on trade are expected for the two EU dummy coefficients, $EU04_{ij}^{t}$ and $EU07_{ij}^{t}$. Values of unity are assigned when eight countries gained official membership in 2004 and the EU15 became the EU25, later becoming the EU27 when two additional countries joined in 2007. In a similar vein, Aitken (1973) examined the trade effects of the dummy variables denoting the European Economic Community (EEC) and the European Free Trade Association (EFTA) over the period 1951 1967 to assess the importance of regional integration within a gravity model framework.

The panel data set consists of bilateral export flows from 17 Western European countries comprising the 14 established EU countries (Belgium and Luxembourg are treated as a single country) and three EFTA member countries[5] to 10 new member states[6] over the period 1994 to 2007. The sample period covers the transformation phase from communism to EU accession and ends in 2007 to avoid the effects of the global financial crisis leading to very abnormal trade flows.

The data sources are as follows. Nominal export flow data, denominated in US dollars at constant 2000 prices, are obtained from the *Direction of Trade Statistics* (DOTS), International Monetary Fund (IMF). The export data are expressed in real terms based on US producer prices (2000 = 100), sourced from the *International Financial Statistics* (IFS), IMF. Data on GDP and GDP per capita at constant 2000 US dollars are from the *World Development Indicators* (WDI), World Bank. The geographic distance, measured in kilometres between the economic centres of the trading partner countries, are from the CEPII as are the colonial and the landlocked dummies.

Nominal exchange rates are official exchange rates in local currency units (LCU) per US dollar, sourced from the WDI, World Bank. The exchange rates for each country that adopted the euro were chain linked with the euro exchange rate upon entry into the European Monetary Union (EMU). In real terms, the nominal exchange rate of countries

[5] Austria, Belgium–Luxembourg, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom.
[6] Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia.

i and j vis a vis the US dollar are expressed as a ratio of goods prices abroad to domestic prices where prices refer to consumer prices (2000 = 100), obtained from the IFS, IMF. The summary statistics for the model variables are shown in Table 1.

[Insert Table 1 here]

3. EMPIRICAL RESULTS

3.1 Gravity Model Estimates

Table 2 presents the results for the stochastic frontier specification of the gravity model of exports from 17 Western European countries to 10 new member states estimated by maximum likelihood over the 1994 2007 period. Column (1) shows the results for the baseline model (equation 4). Column (2) augments the baseline model with time specific effects to control for common shocks affecting all countries in the sample. Column (3) additionally includes country specific effects capturing varying country characteristics among the new member states. Interacting the specific effects in columns (2) and (3), column (4) allows for variation of country characteristics over time. Baier and Bergstrand (2007) have previously highlighted the benefits of using country time interactions to account for time variation of multilateral trade resistances.

[Insert Table 2 here]

Two tests confirm the appropriateness of the SFA approach to estimating the gravity model. In rejecting the null hypothesis, $H_0 : \sigma_u^2 = 0$, against the alternative, $H_1 : \sigma_u^2 > 0$, the likelihood ratio (LR) test favours SFA estimation. This result is additionally supported by the statistical significance of the λ parameter (i.e., the ratio of the standard deviation of inefficiency to the standard deviation of the random error component of the composed error term, (σ_u / σ_v), across the estimated models. As shown for Model 1 in Table 2, λ takes the value of 1.08 and is statistically significant at the 5 per cent level, indicating that the level of inefficiency is 1.08 times that of the random error. A similar result is found consistently across the estimated models in support of the SFA approach.

Regarding the core gravity parameter estimates, the positive and significant coefficient estimates for GDP suggest larger countries trade more. Trade related costs, however, reduce the volume of trade as indicated by the distance coefficients. In support of the Heckscher Ohlin model the per capita income difference coefficients suggest factor endowments are sufficiently different between Western Europe and the new EU member countries, although its declining magnitude and significance suggests the gap is closing over time.

With the exception of column (3), the trade inhibiting effect of geographical characteristics is apparent across all specifications for the landlocked countries (the Czech Republic, Hungary and Slovakia). The negative effect becomes insignificant when country time interactions are introduced in column (4), suggesting the partition effects of geography diminish over time. In contrast, historical colonial links (between Austria vis à vis the Czech Republic and Slovenia; Germany and Poland; and Sweden and Estonia) increase bilateral trade flows, but not significantly.

The sustained depreciation of the dollar after the launch of the euro suggests valuation effects (Micco et al., 2003) and/or volume effects transmitted via changes to the terms of trade negatively affect European exports. A similarly negative coefficient for the importing countries' RER is shown in columns (3) and (4), not surprising given the new members' currency links with the euro, whether pegged to it, intending to adopt it or having already replaced their national currencies with it. This effect is not borne out for the more basic specifications in columns (1) and (2), suggesting country time interactions are warranted in the model.

Finally, the positive and in general significant coefficient estimates for the EU dummies confirm the trade enhancing effect of regional integration. The relatively higher magnitude for the EU07 dummy suggests the efficiency gains of regional integration are stronger for the two newest member countries. Overall, the results for the preferred stochastic frontier specification of trade determinants provide a reasonable approximation of the factors governing bilateral trade patterns between Western Europe and the new member states over the 1994 2007 period.

3.2 Trade Efficiency Scores

The trade efficiency scores for each bilateral pair of countries associated with the preferred stochastic frontier specification (column 4), averaged over the years 1994 2007, are shown in Table 3. A zero value for the one sided term, u_{ij}^{t} , indicates the inefficiency term reduces to the random noise component thereby rendering actual and maximum trade levels coincident. More realistic is a non zero value for the inefficiency term, u_{ij}^{t} , indicating deviations of actual trade from frontier estimates and hence, scope for further trade integration. Point estimates of technical efficiency (TE) are then obtained for each bilateral pair as $TE_{ij}^{t} = \exp(-u_{ij}^{t})$. High efficiency scores suggest trade between two countries is close to their maximum trade potential whereas low efficiency scores indicate deviations of actual trade from frontier estimates, implying scope for further trade integration.

[Insert Table 3 here]

Most country pairs exhibit a high degree of trade integration, but with some notable exceptions. The highly integrated countries include the big four (Czech Republic, Hungary, Poland and Slovakia) – which frequently achieve high efficiency scores of around three quarters of maximum bilateral levels vis àvis Western partners, implying remaining trade potential of just one quarter current average levels. Indeed, Hungary's performance is often closer to four fifths of frontier trade levels, likely reflecting its early programme of liberalisation. At the same time, mixed efficiency scores are also in evidence, depending on the partner country. For example, while attaining relatively high efficiency scores vis à vis many Western partners, Hungary and Slovakia perform poorly against others – Greece, Iceland and Norway in particular.

Several features characterise the high mean efficiency scores. First, geographical proximity plays a key role. Close trade alliances are in evidence, for example, between the Baltics (Estonia, Latvia and Lithuania) and the Nordic countries (Denmark, Finland and Iceland); between Austria and the two latest accession countries; between Greece and Bulgaria; and between Italy and Romania. Second, the new members tend to perform best vis à vis the smaller and more open economies (Belgium and the Netherlands).

Finally, the contribution of regionalism to trade patterns is also apparent. Although bilateral trade agreements are in force between the EU and the individual EFTA member countries, the mean efficiency scores tend to be higher vis à vis the EU15 – Iceland and Norway are particularly low in comparison. Some exceptions to this pattern among the EU15 exist. Together with the UK, lower than average trade performance between the 10 new member countries and Greece is evident, perhaps not unrelated to its declining competitiveness over time.

On the whole, the efficiency scores are consistent with the rapid reorientation of trade towards Western Europe, with each new member state achieving close to two thirds of frontier estimates over the 1994 2007 period. The high efficiency scores suggest a low degree of trade resistances. Fully efficient scores for bilateral trade have not yet been achieved, unlike the findings of previous studies using the conventional approach which suggest trade potential has been exhausted for some country pairs (Nilsson 2000; Stack and Pentecost 2010). The main exceptions to the broad pattern of high integration levels suggest greatest potential for trade expansion vis à vis Greece, Iceland, Norway and the UK.

4. CONCLUSIONS

The breakup of the Soviet Union ushered in a new era of trade expansion between the excommunist countries and their Western neigbouring countries. In anticipation of a reorientation of CEE trade towards Western Europe, early studies sought to quantify the volume of trade likely to prevail in an East–West trade direction assuming full economic liberalisation. Typically, the degree of East–West trade integration is assessed by comparing actual trade volumes with potential trade volumes using the gravity model parameters that fit a model of a normal country's geographic patterns. This approach, however, does not gauge trade levels against a maximum level of trade feasible for the group of eastern European countries.

Using a stochastic frontier approach to estimating the gravity equation for a panel of exports from 17 Western European countries to the 10 new EU member countries over the transformation period of 1994 2007, the efficiency of East–West trade integration is identified relative to maximum potential levels. If two countries achieve an efficient level of trade, they will operate on the trade frontier and thus reach their maximum trade potential otherwise deviations from the trade frontier indicate inefficient levels of trade, implying scope for further trade expansion.

The efficiency scores suggest a high degree of East–West trade integration, with each new member state achieving on average two thirds of frontier estimates over the 1994 2007 period. The high efficiency scores indicate a low degree of trade resistances.

The main exceptions to the broad pattern of high integration levels suggest greatest potential for trade expansion vis à vis Greece, Iceland, Norway and the UK.

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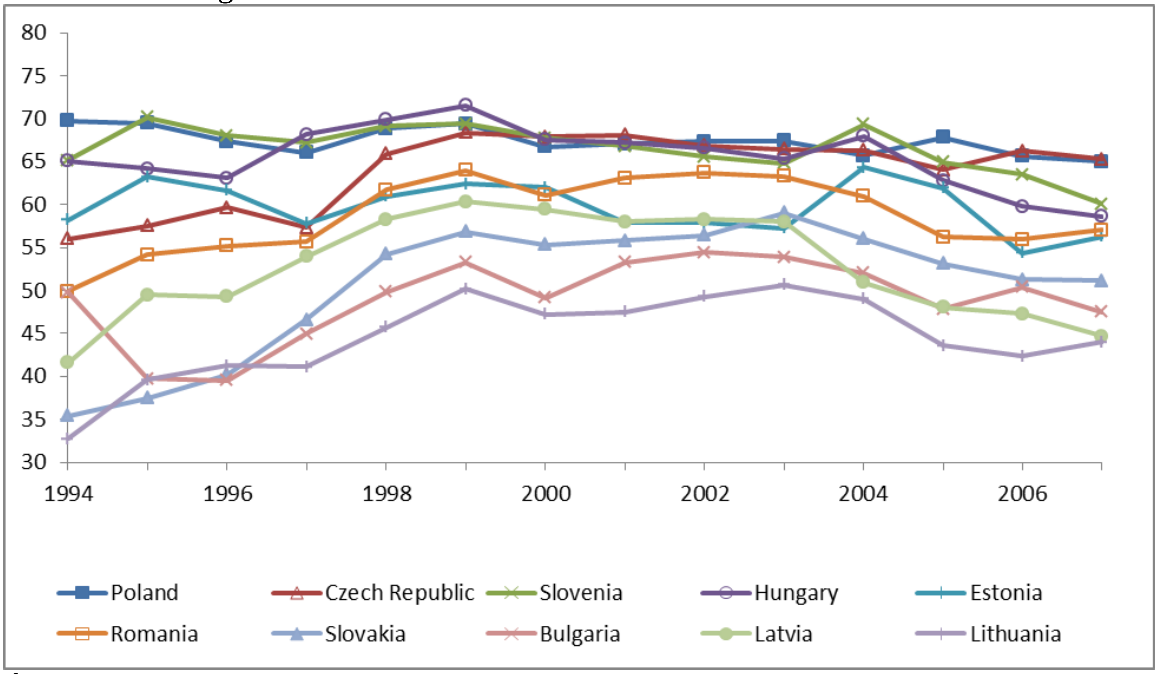
Figure 1 Trade Shares with the EU and the EFTA Countries



[a] Source: *Direction of Trade Statistics*, International Monetary Fund.

Table 1 Summary Statistics

Variable	Mean	Standard deviation	Minimum	Maximum	No. of obs
Exports	18.82	2.21	5.32	24.37	2359
Exporter GDP	26.26	1.27	22.65	28.36	2380
Importer GDP	23.96	0.98	22.11	26.14	2380
Distance	7.15	0.63	4.09	8.22	2380
GDP per capita difference	1.70	0.61	0.38×10^{-2}	3.26	2380
Landlocked	0.30	0.46	0.00	1.00	2380
Colony	0.02	0.15	0.00	1.00	2380
Exporter RER	5.11	1.25	3.90	9.15	2370
Importer RER	6.95	1.91	3.77	10.25	2363
EU-2004	0.19	0.39	0.00	1.00	2380
EU-2007	0.02	0.11	0.00	1.00	2380

Table 2 A Stochastic Frontier Specification of EU and EFTA–NMS Export Determinants

Regressors	(1)[a]	(2)[a]	(3)[a]	(4)[a]
Exporter GDP	0.90**	0.87**	0.88**	0.87**
	(0.02)	(0.02)	(0.02)	(0.02)
Importer GDP	0.83**	0.81**	0.85**	0.98**
	(0.02)	(0.02)	(0.22)	(0.08)
Distance	–1.47**	–1.49**	–1.55**	–1.54**
	(0.03)	(0.03)	(0.03)	(0.03)
GDP per capita difference	0.29**	0.34**	0.07	0.09
	(0.04)	(0.04)	(0.06)	(0.06)
Landlocked	–0.26**	–0.28**	1.51**	–0.17
	(0.04)	(0.04)	(0.50)	(0.80)
Colony	0.10	0.09	0.03	0.03
	(0.10)	(0.10)	(0.09)	(0.09)
Exporter RER	–0.12**	–0.15**	–0.11**	–0.10**
	(0.02)	(0.02)	(0.02)	(0.02)
Importer RER	0.03**	0.07**	–0.80**	–0.07
	(0.01)	(0.01)	(0.16)	(0.36)
EU-2004	0.44**	0.11	0.07	0.29**
	(0.04)	(0.07)	(0.07)	(0.09)
EU-2007	0.78**	0.33**	0.28*	0.86**
	(0.14)	(0.15)	(0.15)	(0.29)
Intercept	–13.83**	–13.13**	–8.55*	–15.33**
	(0.70)	(0.68)	(5.03)	(2.80)
λ [b]	1.08**	1.18**	1.22**	1.30**
	(0.04)	(0.04)	(0.03)	(0.04)
$\sigma^2 u$ [c]	–1.05**	–1.03**	–1.10**	–1.07**
	(0.09)	(0.09)	(0.09)	(0.09)
No. of obs	2332	2332	2332	2332
LR test of $\sigma_u^2 = 0$ [d]	250**	290**	300**	310**
	(0.00)	(0.00)	(0.00)	(0.00)

[a] Standard errors are reported in parentheses.
[b] $\lambda = \sigma_u / \sigma_v$: the ratio of the standard deviation of the inefficiency component to the standard deviation of the random error.
[c] Variation of the inefficiency term.
[d] Likelihood ratio (LR) test that there is no inefficiency component in the composed error term; probability values are in parentheses.
** denotes significance at the 5% level; * denotes significance at the 10% level.

Table 3 Efficiency Score Estimates from the Stochastic Frontier Specification of the Gravity Model, 1994-2007[a]

	AUT	BEL	DNK	FIN	FRA	DEU	GRC	IRL	ISL	ITA	NLD	NOR	PRT	ESP	SWE	CHE	UK
BGR	0.75	0.80	0.71	0.68	0.68	0.78	0.82	0.63	0.34	0.65	0.79	0.19	0.61	0.63	0.72	0.67	0.53
CZE	0.63	0.79	0.52	0.78	0.64	0.63	0.47	0.81	0.22	0.74	0.76	0.67	0.60	0.80	0.79	0.61	0.58
EST	0.66	0.82	0.81	0.46	0.55	0.69	0.26	0.72	0.70	0.75	0.81	0.55	0.58	0.68	0.76	0.51	0.55
HUN	0.58	0.83	0.56	0.80	0.66	0.80	0.25	0.77	0.20	0.65	0.80	0.17	0.74	0.74	0.77	0.61	0.53
LVA	0.60	0.81	0.78	0.72	0.53	0.67	0.33	0.59	0.82	0.73	0.80	0.67	0.54	0.63	0.67	0.64	0.52
LTU	0.41	0.80	0.80	0.71	0.54	0.65	0.28	0.43	0.91	0.70	0.76	0.57	0.55	0.72	0.68	0.55	0.48
POL	0.53	0.83	0.63	0.72	0.70	0.63	0.37	0.74	0.66	0.79	0.81	0.61	0.59	0.79	0.72	0.64	0.56
ROM	0.78	0.81	0.53	0.42	0.77	0.80	0.62	0.69	0.20	0.83	0.80	0.33	0.50	0.64	0.70	0.65	0.62
SVK	0.12	0.82	0.61	0.78	0.69	0.81	0.33	0.71	0.24	0.74	0.79	0.37	0.66	0.80	0.76	0.62	0.47
SVN	0.77	0.76	0.60	0.72	0.79	0.79	0.44	0.64	0.23	0.76	0.77	0.42	0.37	0.79	0.80	0.47	0.42

[a] Efficiency scores are derived from the parameter estimates of the preferred specification, column 4, Table 2.

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